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AUTHOR Lowry, William H.; Thorkildsen, Ron
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ABSTRACT

Part of a larger project, "Technology, Educational Media & Materials--Assessing the Social and Cultural Impact of Group-Based, Videodisc Math Instruction in Mainstreamed Classrooms," this study addressed the question of whether the level of student achievement differs across levels of implementation of a mediated program that is based on a well-defined instructional model. Systematic observations of the implementation of a videodisc-based, direct instruction program, "Mastering Fractions," were conducted. The nine upper-elementary classrooms involved were spread across three school districts. Implementation/utilization of the program varied across classrooms, as did achievement. Based on the observations, three classrooms were classified as high-implementation classrooms, three as average-implementation, and three as low-implementation. At the conclusion of the field study, there was a 28-percentage-point difference between the mean gain score of the high-implementing classrooms and that of the low-implementing classrooms. When covariance-adjusted posttest means were considered, the difference was about 20 percentage points. Guidelines for teachers using the program, an implementation rating sheet, and a teacher interview questionnaire are appended. (20 references) (Author/BBM)

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Implementation levels of a Videodisc-based Mathematics Program and Achievement

Authors:

William H. Lowry
Ron Thorkildsen

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Abstract

We conducted systematic observations of the implementation of a videodisc-based, direct instruction program in fractions.* The nine upper-elementary classrooms involved were spread across three school districts. Implementation/utilization of the program varied across classrooms, as did achievement. Based on the observations we classified three classrooms as high-implementation classrooms, three as average-implementation, and three as low-implemention. At the conclusion of the field study, there was a 28-percentage-point difference between the high-implementing-classrooms mean gain score and that of the low-implementing classrooms. When covariance-adjusted postest means were considered, the difference was about 20 percentage points.

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* This study was completed as a part of a grant funded by the United States Department of Education, project number 84.180R2--Technology, Educational Media & Materials - Assessing the Social and Cultural Impact of Group-Based, Videodisc Math Instruction in Mainstreamed Classrooms. Its parent study was primarily concerned with teacher-student interactions and achievement outcomes for special education students in mainstreamed classrooms. The present study added the investigation of relationships between program implementation and achievement among regular education students. The studies were conducted concurrently, in the same classrooms. For a more complete description of the research conditions, see Lowry (1989).

BACKGROUND

Many researchers of instructor-controlled instructional technologies try to ensure that the program is implemented as close to design specifications as possible, consistent with Mark's (1983) suggestions (e.g., Kelly, 1986). By doing so, the researchers can verify the treatment variable and so can argue that differences in the dependent variable are attributable to the program (see Shaver, 1983).

Media have been used in an attempt to "standardize" the delivery of instruction (Kemp and Smellie, 1989, p. 3) and so to reduce variations in implementation. But apparently, even when a well-defined, media-based program is put into the classroom and monitored, variations in implementation are observed. Hasselbring, Sherwood, and Bransford (1986) reported that they informally observed such variations during their study of the Mastering Fractions vodeodisc program (Systems Impact, 1986).

In their study Hasselbring et al. (1986) were able to control the implementation of the program to some degree. Larger variations in program implementation are apt to occur when instructors use a program in their day-to-day work, outside the field-test environment (Shaver, 1964; Heinich, 1984). A number of authors have suggested that differences between what an instructional designer recommends and what is implemented in the classroom may have a significant effect on student achievement (e.g., Stake, 1967; Hall and Loucks, 1977).

It is important that program implementation, for pre-designed instructional programs, be gathered systematically (Shaver, 1983). Findings of such research can be used to evaluate the specific program. But information regarding implementation versus the learning outcomes of a program can also be used to evaluate instructional design/development in general. If an instructional design, based on theoretical and empirical foundations, is manifested in an instructional product; the product is utilized "well" in the classroom; and the results are positive; then one of the assumptions regarding instructional design is supported . That assumption is that "... systematically designed instruction can greatly affect individual human development" (Gagne, Briggs, & Wager, 1988, p. 5; see also Dick & Carey, 1990).

Mastering Fractions was designed to be consistent with the Direct Instruction Model (Engelmann and Carnine, 1982) and with the findings of the "effective teaching" literature (see e.g., Engelmann and Carnine, 1982; Rosenshine and Stevens, 1986; Hofmeister & Lubke, 1990). Further, some of the features of the effective teacher are "captured" in the videodisc medium (Hofmeister, personal communication). Therefore, the program was considered an example of a well-grounded and well-defined intervention, based on a systems approach to instructional design and development.

PURPOSE OF THE RESEARCH

To extend the work of Hasselbring et al. (1986), we measured program implementation level as the Mastering Fractions program was being used at three sites. The question specifically addressed by this study was as follows: Does the level of student achievement differ across levels of implementation of a mediated program that is based on a well-defined instructional model?

METHOD

First, to check the overall effect of the Mastering Fractions program, we used a quasi-experimental, nonequivalent control group design to compare the postest achievement of two groups of upper elementary students (N = 337; 171 treatment, 166 control). The treatment group received instruction in fractions via the teacher-directed, videodisc-based, Mastering Fractions program. The control group students received their normal grade-four or grade-five mathematics program, which did not include common fractions. This part of the study provided data regarding treatment vs. no-treatment conditions. The mean, treatment-group, covariance-adjusted, posttest score on a criterion-referenced achievement test of fractions skills and concepts was 6.0 standard deviations above that of the control group (the effect size = 5.9 for raw gain scores). These effect sizes were determined using the student as the unit of analysis. We concluded that the program did provide solid instruction in specific fractions skills and concepts.

In addition to the comparison between the treatment and control groups, we collected data on differences in achievement within the treatment group

(n = 171) by level of program implementation. This addressed the research question posed in the present study.

Subjects

The facilitators involved in this study were nine grade-five teachers at three sites. Each had a minimum of five years of teaching experience.

The students were grade-five, public school students who had not received instruction in fractions. Their grade equivalent scores (based on the Iowa Test of Basic Skills or the Comprehensive Test of Basic Skills) are comparable to those presented in the technical manuals for the instruments (see Lowry, 1989).

Instrumentation

The two variables measured for this study were criterion-referenced student achievement and teacher implementation of the program. The former was measured using a paper-and-pencil test; the latter was considered using a combination of measures.

Achievement measure

We used a criterion-referenced test, developed for previous research with Mastering Fractions, as a measure of fractions achievement. The test contains 57 items covering fractions skills and concepts. Since it is criterion referenced, there were low scores and low variability among scores at pretest. The test-retest correlation for control-group students is +0.67.

Level of implementation of the Mastering Fractions program

Shaver (1983) suggests the use of multiple measures of implementation, including systematic observation. He defines systematic observation as "... the unitization of behavior and the classification of the units into previously defined categories,..." (p. 4). We used three measures of implementation: a systematic-observation instrument, a self-report teacher questionnaire regarding program modification, and classroom seating charts.

Observational instrument. Although implementation observation instruments are available, Shaver (1983) points out that these instruments "... may not reflect validly the critical dimensions of the teaching methods to be investigated" (p. 4). The developers of Mastering Fractions provide specific suggestions for implementing the program. These suggestions are presented in the teacher's manual. We combined the suggestions from the manual with two other sources: (1) information from informal observations made by experienced observers from earlier studies of the program and (2) analyses of videotapes of teachers who had used the program successfully in the past. Once the behaviors were listed, we categorized them according to a media utilization model (Kemp & Smellie, 1989) and the effective teaching literature (see Hofmeister & Lubke, 1990). The result was a dual-purpose listing. We used the list as a rating instrument for systematic observation and as a set of suggestions for teachers implementing the program. The suggestions sheet is presented in Appendix A; the rating sheet appears in Appendix B.

During the course of the Mastering Fractions program in each of the 9 treatment-group classrooms in the fall of 1988, observers for the parent project were asked to record their perceptions of the degree of implementation of each area of the utilization model (see Appendix B). The sum of the rating points (on a five-point scale; 5 as high), for all of the categories in the utilization model, was taken as an implementation score on this instrument.

At least two observers would visit a single class together, once per week, to check interobserver agreement. One investigator also visited each classroom where the videodisc program was being used, to check interobserver agreement. Percentage of exact interobserver agreement was 75.6; agreement within one step on the rating scale was 96.7%. The latter percentage is provided, since it is quite conceivable that, on a five-point scale representing a continuous variable, one observer might perceive a behavior as just less than say 2.5 out of 5 (and so would record a score of 2) while another observer might see the same behavior as slightly more than 2.5 (and so would record it as a score of 3).

Teacher questionnaire. After each of the classes had completed the Mastering Fractions program, site coordinators interviewed the respective teachers with a structured questionnaire as a self report of

modifications to the program. A copy of the questionnaire appears in Appendix C. The questionnaire provided a second indication of how teachers modified the recommended delivery practices.

Seating charts. The teacher's guide also includes suggestions for seating patterns, to allow the teacher to provide needed help to students who may be experiencing difficulties with the program. The teachers provided seating charts to the observers, so that the observers could identify students, by name, for the parent-study observations. We used the seating charts to determine the degree to which teachers were able to arrange the class seating in accord with the suggestions.

We then compiled the data to get an overall-implementation consistency rating for each teacher, based on the questionnaire, the implementation observations, and the seating charts.

The Instructional Programs

Teacher in-service instruction

Treatment-group teachers were given a half-day workshop on the use of the program, and were invited to call the researchers with their questions or comments. This procedure is consistent with the typical in-service training for the program.

During each of the teacher-training sessions we provided copies of the suggestions sheet (Appendix A) and discussed each item on the list. We demonstrated the set-up and use of the equipment. We addressed each of the program utilization techniques by showing and discussing a videotape of a model teacher using the program. We encouraged teachers to follow the suggestions as closely as possible.

The Mastering Fractions program

Rosenshine and Stevens (1986) provide a list of teaching processes in their operational definition of the daily functions of direct instruction:

1. Review, check the previous day's work (and reteach, if necessary)
2. Present new content/skills

3. Guide student practice (and check for understanding)
4. Provide feedback and correctives (and reteach, if necessary)
5. Provide independent student practice
6. Provide weekly and monthly reviews.

But rote following of these instructional functions does not guarantee that students will learn. Rosenshine and Stevens (1986) noted that the success of these techniques depends on specific ways of performing each of them. For example, content or skills should be presented in a clear and organized manner (item 2 above). Haphazard presentation does not benefit the learner (see also Bandura, 1982).

Direct forms of instruction have been observed by researchers studying effective-teaching in practice (e.g, Good, 1979). But the Direct Instruction Model (Engelmann, 1980) has evolved from a theoretical/empirical base. For a detailed description of the model see Engelmann and Carnine (1982) (see also Becker & Carnine, 1980).

The Mastering Fractions program was developed in cooperation with Engelmann and Carnine. It was designed to be presented to a heterogeneous class of students. The program requires that a television or monitor, with a screen large enough to be read in all parts of the classroom, be placed at the front of the class. All students are seated facing the screen. The audio system must be clear and loud enough to be heard by all students. The program requires the Mastering Fractions videodiscs, a level-one videodisc player, consumable student worksheets, extra paper and pencils, and the teacher handbook (which includes answer keys for the seat work and tests).

Mastering Fractions consists of 35 lessons. Each lesson is designed to be completed in approximately 40 minutes. Most presentation/practice lessons begin with a quiz of the previous lesson's learning, and each fifth lesson is a mastery test. Both quizzes and mastery tests are followed by diagnostic/remedial suggestions based on specific skill weaknesses manifested by the students. Instruction is provided on the disc at three progressive levels--oral response, written practice with component skills and concepts, and written practice with articulated skills and problem-solving strategies (for more detail see Systems Impact, 1986).

The developers of the Direct Instruction Model have provided specific guidelines for the presentation and practice of concept attainment and skill performance. That is, general definitions of direct forms of instruction address instructional management or a superstructure for instruction, while the Direct Instruction Model also provides instructional design rules and message design guidelines. The videodisc-based portion of the Mastering Fractions program was designed using the D. I. Model, and the paper-based materials and recommended teaching procedures are designed to support that model. However, most important to the present study, while the program is media based, it is teacher controlled. The designers purposely gave the teacher control over portions of the program to help integrate Mastering Fractions into the school context.

Analysis

Each teacher did modify the delivery of the Mastering Fractions program to some degree. When the treatment-group classes had finished the program, the observations were averaged for each teacher on a per-observation-period basis. The post-study questionnaire data and seating chart data were also included. The seating charts showed that none of the teachers used the suggested seating arrangement consistently. Scores on the post-study questionnaire were consistent with the observational data. We then classified the classes as high-implementing, average-implementing, and low-implementing--three classes in each subgroup.

Adequate analysis was made by simple inspection of the data (Shaver, 1983) (see RESULTS AND DISCUSSION). We also ran an analysis of covariance, using pretest means on a standardized achievement measure and pretest means on the criterion-referenced test as covariates.

RESULTS AND DISCUSSION

Achievement and Program Implementation

Table 1 shows mean percentage scores and gain scores on the fractions criterion-referenced test. The treatment-group means are broken down by the level of program implemenation. The the no-treatment control group means are also included for your information. The overall mean of the treatment group is also included.

Table 1

Percentage Correct Means on the Criterion-Referenced Achievement Test by Program Implementation Level for the Treatment Group

Implementation Level	Pretest		Posttest		Gain	n-size
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	
High	6.6	5.0	84.9	10.0	+78.3	55
Average	11.5	15.3	79.7	14.6	+68.2	54
Low	8.6	11.2	58.9	24.8	+50.3	62
Control	10.6	10.7	9.2	10.6	-01.4	166
Overall within the treatment group	8.9	11.4	73.8	21.3	+64.9	171

As would be expected the control group scores show essentially no change on the fractions criterion-referenced test from from pre- to posttest. The treatment group means, however, show large gains (64.9 percentage points on the average). As noted earlier, overall, the results of the criterion-referenced test provide evidence that students who study the Mastering Fractions program do learn specific fractions skills and concepts. The standardized mean difference effect size between the treatment and control groups was +5.9 in favor of the treatment group. The mean scores on the criterion test were also consistent with gains made in previous research on this instructional system (e.g., Hasselbring et al., 1986).

There are also clear differences among the means for high, average, and low levels of implementation. There is a 10 percentage-point difference between the high- and average-implementation mean gain scores, and an 18 percentage-point difference between the average- and the low-implementation mean gain scores.

The analysis of covariance yielded an effect of levels-of-implementation that is statistically significant when the student is used as the unit of analysis ($F = 25.92$; $p = .001$). The eta-squared effect size, based on the adjusted means, is +0.12, which means that 12% of the variance in the criterion-referenced posttest scores is associated with differences in implementation level. Table 2 shows the covariance-adjusted posttest means for the criterion-referenced posttest scores (for details see Lowry, 1989). There remained a 20-percentage point spread between the mean of the high-implementation classes and that of the low-implementation classes. No site dominated any of the implementation levels.

Table 2

Summary of Adjusted Cell Means for the Analysis of Covariance

Level of Implementation	Mean
High	83.6%
Average	76.1%
Low	63.9%

Discussion

The findings of this study are consistent with observations made by Hasselbring et al. (1986). Variations in implementation/utilization did occur with an instructional system that provides for some autonomy on the part of the teacher.

Further, the achievement on a criterion-referenced test appears to be directly related to the level of implementation of the program. This relationship supports an assumption that systematically designed instruction can affect individual human development. In this case the area was achievement enhancement, the goal of a direct-instruction-type program.

The results also support the position that systematic design is necessary but insufficient. If a causal relationship exists between levels of

implementation of a well-designed program and achievement, for this or other systems-designed programs, designers must be cautious. If an instructional system is too sensitive to the context in which it is implemented, i.e., too open, its potential effect may be watered-down (as noted by Heinich, 1984).

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SUGGESTIONS FOR THE USE OF "MASTERING FRACTIONS" 9/20/88

Preparing Yourself
- practice setting up the equipment.
- practice using the program before you teach with it.
- look for subtle variations.
- go through the write/check screens and the worksheets.
- practice with the hand controller.
- look for potential problem areas for your students.

Preparing Your Environment
- ensure the equipment is ready.
- ensure the workbook pages are photocopied.
- ensure the lighting level is appropriate.
- ensure there is no glare on the TV screen.
- ensure all students can read the screen and hear the audio track.
- ensure there is adequate space for you to walk around the room.

Preparing the Students
- note the lesson number for today aloud.
- call their attention to the information on the screen (help them focus on the screen)
- ensure students have paper, sharp pencils, etc.
- position students having difficulty near the center of the group.
- stop disruptions.
- introduce support skills.
- support the program verbally and by your actions.

Evaluating Previous Learning
- use the review quiz.
- allow adequate work time for each problem.
- use quiz results to determine remediation.
- use the "1/5 criterion"
- use progress sheets.
- allow student mastery, not a weekly schedule, to determine program pacing.

Presenting and Remediating the Instructional Material
- circulate among the students.
- model/encourage appropriate student verbal response.
- use the scan and step functions to freeze frame or review/reiterate concepts or vocabulary.
- stop the program to clarify or enhance the instruction if students are having difficulty.

Guiding Practice
- circulate to check student progress on their work products.
- diagnose student problems.
- coach students, a step at a time, through new types of problems, using previously learned skills.
- keep the pace moving.
- have alternate work available for high achieving students (they can switch their attention from math to another project and back, as necessary).
- work briefly with individuals, then circulate; review/remediate with the group as necessary.

Appendix B

Implementation Rating Sheet

SUGGESTIONS FOR THE USE OF "MASTERING FRACTIONS"

9/20/88

Preparing Yourself 1 __ 2 __ 3 __ 4 __ 5 __

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- work briefly with individuals, then circulate; review/remediate with the group as necessary.

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Appendix C

Teacher Questionnaire

Teacher _____

Date of Interview _____

During your post- Mastering Fractions interview, we collected information regarding your feelings about the program. The program developers are also interested in how you used Mastering Fractions. They would like any information on how you may have modified the program.

1. How many weeks do you normally spend on fractions, at the grade level you're teaching this year?

   _____ weeks

2. Was there terminology or content in the Mastering Fractions program which you modified. If so, what specific terms or concepts stand out in your mind?

3. Were there instructional methods used in the program which you modified? Specifically . . . . .

   a. Did you modify the 1/5 criterion for remediation, which appears on the "CSP" screens? If so, how?

   b. Did you require students to "write" or "copy" problems where the program asked students to "copy the problem and work it"? If not, what other approach(es) did you use?

c. Did you require choral responses during the verbal practice presented in the program?

d. Did you use choral responses in place of written responses? In what parts of the program?

4. Did the students use the workbooks as homework or did they use them as independent seatwork? (Please circle one or both - if both apply, then state the approximate percent of time for each.)

5. Did you supplement the videodisc material with other materials? If so, during what parts of the program, or regarding what concepts/strategies?

6. During the Fall session, USU Staff developed "Supplements" intended to help students learn multiple labels for the concepts they had learned during Mastering Fractions; that is, to generalize the concepts they were learning.

Did you use the Supplements? _____

If so, do you think your students benefited from their use?

7. Do you think that Mastering Fractions is appropriate for the grade level you teach? _____

   If not, what recommendations would you have for its use?

8. Was there a point in the Mastering Fractions where your lowest students began to experience difficulty? _____

   If so, at about what lesson? _____